Use of Models for Project Traffic Forecasting in Ohio

September 25, 2008

Role of Forecasts in Project Development

- Project Planning versus General Planning
- Preliminary Project Planning
- Analysis of Conceptual Alternatives
- Detailed Design

Project Planning versus General Planning

- Project development includes a planning stage, however, the distinction between project planning and general planning should be kept in mind
- General Planning tends to focus on a broad area
- When a project comes into existence, there is an implicit assumption that a transportation improvement is necessary in a specific area

Project Planning versus General Planning

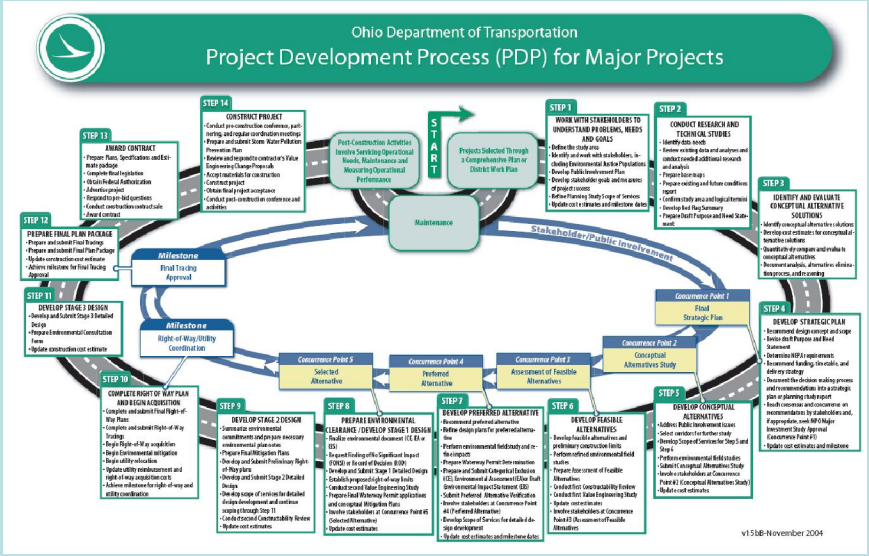
- Models were originally designed for general planning
  - Needs Analysis
  - Long Range Plan Alternatives Analysis
  - Air Quality Conformity
  - Congestion Management
- They are calibrated to a regional level to provide reasonable system statistics for these purposes

Project Planning versus General Planning

- Use of models to estimate traffic volumes for individual projects requires location specific accuracy
- The level of additional work required to produce this accuracy depends on the stage of project development and size of the project

Preliminary Project Planning

- ODOT has a Project Development Process (PDP) designed to combine both project planning and NEPA requirements
- The first four steps of ODOT's Major PDP are referred to as the project planning phase
- During these steps, the existing and future conditions are evaluated using the no build condition and the alternatives to be analyzed are developed



Preliminary Project Planning

- It is during the analysis of the no build conditions that models should be enhanced to improve their operation in the project area
- The more ambiguous nature of the alternatives at this stage imply that the accuracy requirements of the traffic forecasts are not as high
- Thus direct results from the improved project level model are used in the decision making of this stage, such results are referred to as **Planning Level Traffic**

Analysis of Conceptual Alternatives

- Step 5 of the Major PDP is "Develop Conceptual Alternatives"
- At this stage the alternatives identified in the planning phase are evaluated and compared narrowing them down to significantly
- Analysis of impacts on traffic using the model is part of this evaluation
- This evaluation requires greater differentiation among the project alternatives
- Thus the level of detail that must be accommodated by the model increases

Analysis of Conceptual Alternatives

- However, according to the ODOT PDP, the differences between alternatives at this stage will typically involve things like:
  - Designation of 1000'-2000' foot corridors
  - Interchange locations
  - Typical sections (i.e. number of lanes)
- These items are within the accuracy tolerance of a well calibrated model
- Therefore, model results can typically be used for this stage of project development as well

Analysis of Conceptual Alternatives

- Sometimes, however, the differentiation of alternatives or the constrained nature of the study area will require more precise definition of the conceptual alternatives (e.g. turn lanes, auxiliary lanes, signal locations, ramp configurations, etc.)
- In these cases, even a well calibrated model will often contain more error than the differences between alternatives
- In these cases consideration must be given to obtaining **Design Traffic** at this stage or developing a **Conceptual Alternatives Model**

Detailed Design

- The remaining steps (6-14) of the PDP involve the design and construction of the project
- During these steps very detailed decision such as signal timing plans will be made
- Therefore detailed design hour volumes, truck percentages, turning movements etc. are needed
- Therefore, model results are not used directly, instead they are refined into **Design Traffic**

Forecast Types

- Guess
- Raw Model Output
- Planning Level Traffic
- Refined Alternative Level Traffic
- Design Traffic

Raw Model Output

- Model results that have not been subjected to additional project level checks, refinements and adjustments
- Usually come from the Model of Record
- Should NEVER be used to provide forecast volumes for projects
- Raw model output is sometimes used in conjunction with other information to determine simple growth rates for smaller projects
- Even then if should be subjected to some cursory checks versus independent data such as count trends

Planning Level Traffic

- Model results from a model that has been subjected to additional project level checks, refinements and adjustments
- As mentioned previously, planning level traffic is sufficient for project planning (Major PDP steps 1-4) where the level of decision is on the order of magnitude of the number of general purpose lanes needed.
- It is usually sufficient for evaluating conceptual alternative as well (Major PDP step 5)

Refined Alternative Level Traffic

- Model results from a Conceptual Alternatives Model, a model that has undergone even more extensive adjustments for the purpose of analyzing conceptual alternatives without the need to produce design traffic for each
- This is a new category used for certain very large projects
- Generally involved the use of matrix estimation techniques to refine model results

Design Traffic

- Traffic forecasts that have gone through additional post-processing to produce volume forecasts and associated parameters (design hour factors, truck percentages, direction split etc.) at the turn movement level if necessary, for project design
- Design traffic is covered in a separate course
- Relies to a large extent on the traffic forecasts from the models
- Certified Design Traffic is ONLY design traffic that has been explicitly certified by the ODOT Office of Technical Services Modeling and Forecasting Section

Project Types

- ODOT's PDP Categorizes Projects as:
  - Minimal
  - Minor
  - Major
- From a modeling perspective it is useful to break major projects down further
  - Normal Major
  - Large Major
  - Mega

Project Definitions from ODOT PDP

106.0 Project Definitions

106.1 Major Projects (14-Step PDP)

Major Projects are defined as transportation improvements where the anticipated result of the improvement is expected to:

- Have a significant impact to the highway's public access, level of service, traffic flow, mobility patterns, or mode shares.
- Require substantial right-of-way acquisition.
- Have a high degree of public controversy.

Additionally, this classification applies to those highway transportation improvements that will require a substantial financial investment to complete all aspects of project development. These projects typically involve one or more of these situations:

- Making significant alterations to the existing highway (e.g., lane addition).
- Relocating a major portion of a highway (e.g., significant change to horizontal and/or vertical alignment).
- Developing a new highway alignment (e.g., bypass).
- Constructing a new or significant modification to an existing interchange.

Project Definitions from ODOT PDP

106.2 Minor Projects (10-Step PDP)

Minor Projects are defined as transportation improvements that generally are located on an existing alignment. Small adjustments to the existing alignment to improve geometric conditions may be involved. Substantial relocations of non-interstate roadways that do not result in significant environmental impacts also can qualify as Minor Projects. Minor Projects may have environmental impacts. These impacts can be developed and approved through the Categorical Exclusion process. Refer to the *Environmental Process Manual* for more details.

Examples and thresholds for environmental impacts are included in ODOT's Office of Environmental Services *Environmental Process Manual*. Minor Projects can involve right-of-way acquisition, utility relocations, altering the highway's cross section, and raising or lowering the roadway profile. Examples of Minor Projects include:

- Bridge replacement and rehabilitation.
- Culvert replacement.
- Pavement widening.
- Rehabilitation.
- Geometric realignment.
- Intersection upgrades including the addition of turn lanes.

106.3 Minimal Projects (5-Step PDP)

Minimal Projects are defined as transportation improvements generated by the traditional maintenance and preventive maintenance program as they relate to the development of the District Work Plan. These projects:

- Do not alter the basic highway cross section or geometry.
- Require no additional right-of-way.
- Have minimal impacts on existing utilities.
- Have no impacts to environmental resources.
- Require no environmental agency coordination.
- Are considered "exempt" from National Environmental Policy Act (NEPA) studies as defined in ODOT's Office of Environmental Services *Environmental Process* Manual.
- Are likely to require only minor public involvement.

Minimal and Minor Projects

- These projects typically involve no explicit model work
- Sometimes the model of record is consulted to develop traffic growth rates
- Sometimes projects defined as Minor by ODOT due to their minor right of way/environment impacts might have major traffic impacts and should thus be treated as such for modeling purposes

Major Projects

- Large major projects involve some of the following:
  - Major New Bridge
  - New Interchange
  - Removal/Addition of Connections for Certain Movements at an Interchange
  - Any New Freeway
  - One or More Miles of New Non-Freeway Road
  - Increase of 50% or More to the Number of Through Lanes
- Normal major projects don't
- Mega projects are specially designated such due to their huge expense

Volume Reporting

- When possible, model volumes are not reported directly
- Report growth rates or differences
- Often apply NCHRP 255 adjustments to produce reported volumes
- When they are reported directly; it is a good idea to round the results to the nearest 10, 100 or even 1000 to emphasize the imprecise nature of the results

Using the Model for Projects

- The "model of record" will generally need revision to provide the location specific accuracy needed for project level forecasts
- This is accomplished with 3 processes:
  - Model Checking
  - Model Refinement
  - Model Adjustment
- NOTE: The checks/refinements/adjustments covered in this training focus on the needs of highway projects, transit and policy type projects will have their own requirements outside the scope of this training

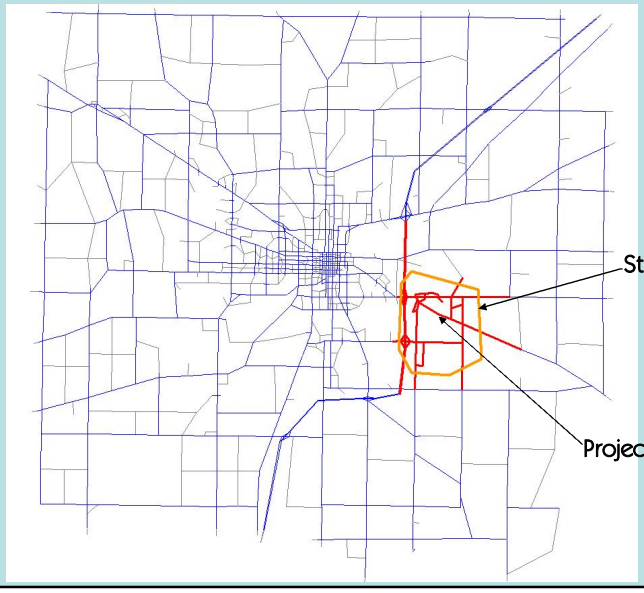
Using the Model for Projects

- Model checking is simply the process of comparing model results to base conditions and model trends to independently estimated trends to determine their suitability for use
- Model refining includes correcting errors discovered during checking as well as adding additional detail to the model network and zones
- Model adjusting is the process of changing the functioning of the model itself to better match desired results

Model Checking

- Model checking is generally conducted at two levels
  - For the entire regional model
  - Within the project study area
- The checks conducted at the regional level are simply a subset of the more extensive series of checks that will be conducted within the study area, focusing on:
  - VMT
  - Screenlines
  - %RMSE
  - V/G Ratio

Region vs. Study Area



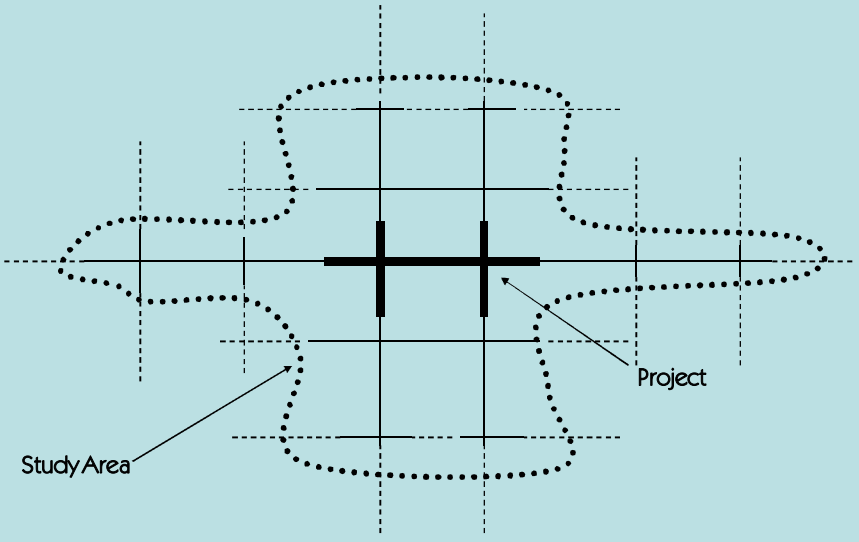
Regional Checking

- Should always begin with the model of record which should already be validated at regional level
- Checking the model regionally simply confirms the validation and sets the base line for further checks
- If significant changes to the model are made during the refinement/adjustment stage, the regional validation should be reevaluated

Study Area Definition

- The study area should at a minimum include the following:
  - The next parallel facility to either side of the project facility
  - Two intersections/interchanges beyond the last one directly impacted on the project facility
  - One intersection/interchange beyond the parallel route on cross streets
  - All network facilities bounded by these

Study Area Definition

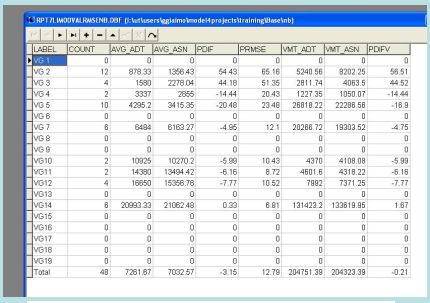


Study Area Checks for All Projects

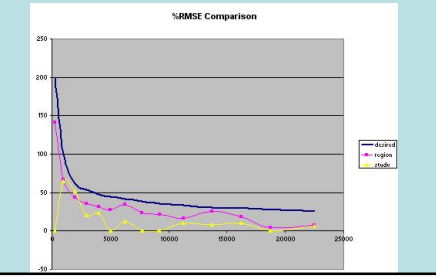
- %RMSE (or Percent Difference)
- VMT
- Screenline
- V/G Ratio

- Network Coding
- Base Land Use
- Forecast Land Use
- Growth Rates

Percent Root Mean Square Error



LABEL	COUNT	AVG_ADT	AVG_ASN	PDIF	PRMSE	VMT_ADT	VMT_ASN	PDIFV
VG 1	0	0	0	0	0	0	0	0
VG 2	12	878.33	1356.43	54.43	65.16	5240.56	8202.25	56.51
VG 3	4	1580	2278.04	44.18	51.35	2811.74	4083.5	44.52
VG 4	2	3337	2855	-14.44	20.43	1227.35	1050.07	-14.44
VG 5	10	4295.2	3415.35	-20.48	23.48	26818.22	22286.56	-16.9
VG 6	0	0	0	0	0	0	0	0
VG 7	8	8484	6163.27	-4.95	12.1	20288.72	19303.52	-4.75
VG 8	0	0	0	0	0	0	0	0
VG 9	0	0	0	0	0	0	0	0
VG10	2	10925	10270.2	-5.99	10.43	4370	4108.08	-5.99
VG11	2	14380	13494.42	-6.16	8.72	4601.6	4318.22	-6.16
VG12	4	16650	15356.76	-7.77	10.52	7992	7371.25	-7.77
VG13	0	0	0	0	0	0	0	0
VG14	6	20993.33	21062.48	0.33	6.81	131423.2	133819.95	1.87
VG15	0	0	0	0	0	0	0	0
VG16	0	0	0	0	0	0	0	0
VG17	0	0	0	0	0	0	0	0
VG18	0	0	0	0	0	0	0	0
VG19	0	0	0	0	0	0	0	0
Total	48	7261.67	7032.57	-3.15	12.79	204751.38	204323.39	-0.21



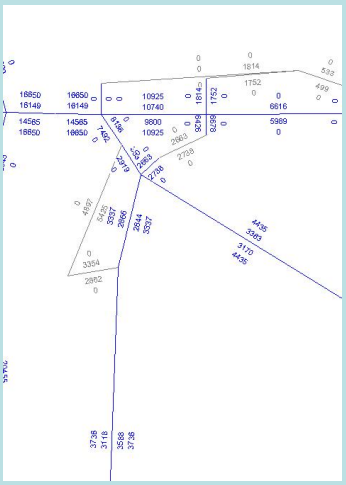
midpoint	desired
250	200
1000	100
2000	62
3000	54
4000	48
5000	45
6250	42
7750	39
9250	36
11250	34
13750	31
16250	30
18750	28
22500	26
30000	24
45000	21
65000	18
97500	12

VMT

- VMT checking is somewhat less important at study area level, particularly when there are few links in a category (in which case individual percent differences are more important)
- Still, it provides a benchmark on model performance, particularly for larger study areas
- The allowable differences are:
  - Freeway 7%
  - Arterial 10%
  - Other 15%
  - Total 3%

V/G Ratio

- Volume to count ratio is an alternative way to express percent differences in map format
- Either can be used
- The key issue is to map the assigned volume versus counts and analyze it for correctness



Network Coding

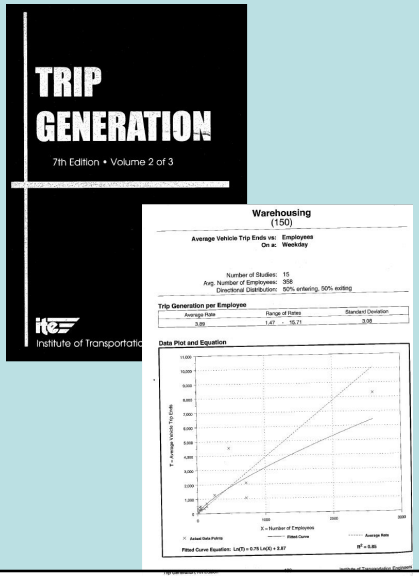
- Networks should be thoroughly checked in the study area
- Independent sources such as ODOT Roadway Information Database, aerial photos and windshield surveys should be conducted to ensure the network data is correct in the study area
- Additional roadways might also be brought into the network during the refinement stage to provide greater network detail

Base Year Land Use

- Base year land use (zonal socio-economic data such as population, employment etc.) should be checked in the study area in three ways (the level of checking depending on the magnitude of the project):
  - Check internal consistency
  - Check accuracy versus independent data in GIS
  - Check trip generation versus ITE Trip Generation

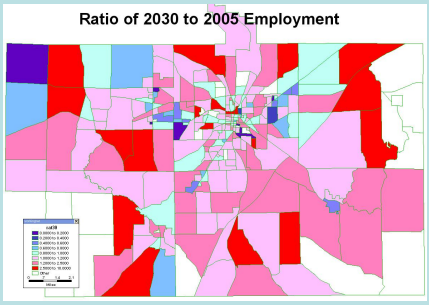
Trip Rate Check

- Trips coming out of zones in the study area can be compared to ITE Trip Generation rates for non-residential land uses
- Previous Traffic Impact Studies should be consulted for this as well to ensure consistency with past assumptions
- Major discrepancies can be accommodated with special generators



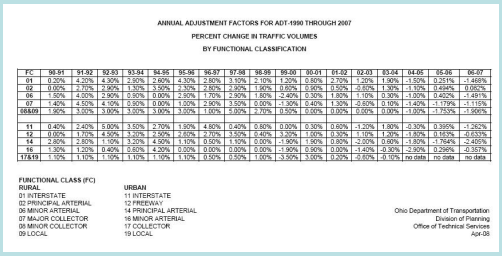
Forecast Year Land Use

- Consistency checks similar to those for the base year should be conducted
- In addition, the forecast socio-economic data should be compared to the base year to ascertain whether the implied growth makes sense
- Sometimes, forecast year variables are updated with methodologies that are different from those used to develop base year variables resulting in major inconsistencies



Growth Rate Check

- At the most important project locations, the annual traffic growth rate implied by the model should be compared to independent sources such as:
  - Past traffic count trends
  - HPMS VMT growth rates
  - ODOT Congestion Management Process growth rates
  - ODOT annual adjustment factors report
  - Population/employment growth trends (ODOD projects etc.)



ANNUAL ADJUSTMENT FACTORS FOR ADT-1990 THROUGH 2007

PERCENT CHANGE IN TRAFFIC VOLUMES

BY FUNCTIONAL CLASSIFICATION

FC	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07
01	0.30%	4.20%	4.30%	2.80%	2.60%	4.30%	2.80%	3.10%	2.10%	1.20%	0.80%	2.70%	1.20%	1.90%	-1.50%	0.251%	-1.466%
02	0.00%	2.70%	2.90%	1.30%	3.50%	2.30%	2.80%	2.90%	1.90%	0.80%	0.90%	0.50%	-0.60%	1.30%	-1.10%	0.494%	0.052%
06	1.50%	4.00%	2.90%	0.80%	0.00%	2.50%	1.70%	2.50%	1.50%	2.40%	0.30%	1.80%	1.10%	0.30%	-1.00%	0.462%	-1.491%
07	1.40%	4.50%	4.10%	0.90%	0.00%	1.00%	2.90%	3.50%	0.00%	-1.30%	0.40%	1.30%	-0.60%	0.10%	-1.40%	-1.179%	-1.115%
08&09	1.90%	3.00%	3.00%	3.00%	3.00%	3.00%	1.00%	5.00%	2.70%	0.50%	0.00%	0.00%	0.00%	0.00%	-1.00%	-1.753%	-1.906%
11	0.40%	2.40%	5.00%	3.50%	2.70%	1.90%	4.60%	0.40%	0.80%	0.00%	0.30%	0.60%	-1.20%	1.80%	-0.30%	0.395%	-1.262%
12	0.00%	1.70%	4.50%	3.20%	2.50%	2.80%	2.70%	3.50%	0.40%	3.20%	1.00%	0.30%	1.10%	1.30%	-1.80%	0.183%	-0.633%
14	2.80%	2.80%	1.10%	3.20%	4.50%	1.10%	0.50%	1.10%	0.00%	-1.90%	1.90%	0.80%	-2.20%	0.60%	-1.80%	-1.764%	-2.465%
16	1.30%	1.20%	0.40%	0.80%	4.20%	0.00%	0.00%	0.00%	0.00%	-1.90%	0.90%	0.00%	-1.40%	-0.30%	-2.90%	0.296%	-0.357%
17&19	1.10%	1.10%	1.10%	1.10%	1.10%	1.10%	0.50%	0.50%	1.00%	-3.50%	3.00%	0.20%	-0.60%	-0.10%	no data	no data	no data

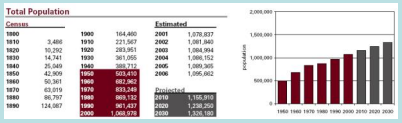
FUNCTIONAL CLASS (FC)

RURAL
01 INTERSTATE
02 PRINCIPAL ARTERIAL
06 MINOR ARTERIAL
07 MAJOR COLLECTOR
08 MINOR COLLECTOR
09 LOCAL

URBAN
11 INTERSTATE
12 FREEWAY
14 PRINCIPAL ARTERIAL
16 MINOR ARTERIAL
17 COLLECTOR
19 LOCAL

Ohio Department of Transportation
Division of Planning
Office of Technical Services
ADF-08

http://www.dot.state.oh.us/techservsite/offceorg/traffmonit/



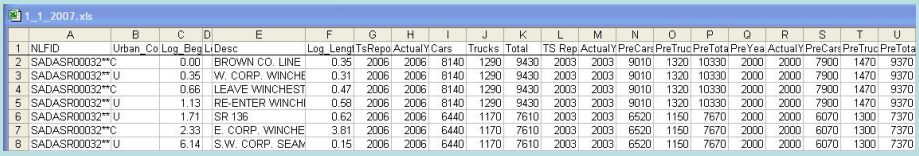
Total Population

Census

1800		1900	164,460	2001	1,078,837
1810	3,486	1910	221,567	2002	1,081,840
1820	10,292	1920	283,951	2003	1,084,994
1830	14,741	1930	361,055	2004	1,088,152
1840	25,049	1940	388,712	2005	1,089,305
1850	42,909	1950	503,410	2006	1,095,662
1860	50,361	1960	582,262		
1870	63,019	1970	633,240	Projected	
1880	86,797	1980	663,132	2010	1,155,910
1890	124,087	1990	661,437	2020	1,238,250
		2000	1,068,978	2030	1,324,190

Estimated

http://www.odod.state.oh.us/research/



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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	NLFID	Urban_Co	Log_Beg	Li	Desc	Log_Lengt	TsRepo	ActualY	Cars	Trucks	Total	TS Rep	ActualY	PreCars	PreTruc	PreTota	PreYea	ActualY	PreCars	PreTruc	PreTota
2	SADASR00032***	C	0.00		BROWN CO. LINE	0.35	2006	2006	8140	1290	9430	2003	2003	9010	1320	10330	2000	2000	7900	1470	9370
3	SADASR00032***	U	0.35		W. CORP. WINCHE	0.31	2006	2006	8140	1290	9430	2003	2003	9010	1320	10330	2000	2000	7900	1470	9370
4	SADASR00032***	C	0.66		LEAVE WINCHEST	0.47	2006	2006	8140	1290	9430	2003	2003	9010	1320	10330	2000	2000	7900	1470	9370
5	SADASR00032***	U	1.13		RE-ENTER WINCHI	0.58	2006	2006	8140	1290	9430	2003	2003	9010	1320	10330	2000	2000	7900	1470	9370
6	SADASR00032***	U	1.71		SR 136	0.62	2006	2006	6440	1170	7610	2003	2003	6520	1150	7670	2000	2000	6070	1300	7370
7	SADASR00032***	C	2.33		E. CORP. WINCHE	3.81	2006	2006	6440	1170	7610	2003	2003	6520	1150	7670	2000	2000	6070	1300	7370
8	SADASR00032***	U	6.14		S.W. CORP. SEAM	0.15	2006	2006	6440	1170	7610	2003	2003	6520	1150	7670	2000	2000	6070	1300	7370

More Advanced Study Area Checks

- Large major projects may benefit from additional checks beyond those mentioned previously such as:
  - Path Checks
  - Select Link Analysis
  - Travel Time Checks
  - Distribution Checks

Special Purpose Checks

- Additional checks may be warranted if the project analysis requires specialized outputs:
  - Turn Movement check if model turn movements will be used
  - Peak Period/Hour Percentages if subdaily model results will be used
  - Directional Splits if directional model volumes will be used
  - Truck volumes if model truck volumes will be used

Level of Refining to Apply

- For most projects the refinement step boils down to simply correcting any errors discovered during checking
  - Network
  - Zonal data
  - Centroid connectors
- Large major projects as well as those requiring very detailed forecasts such as turn movements benefit from additional refinement to the network, zones, intersection and special generators
- Many projects only involve the assignment stage in the model in which case any refining/adjusting related to zonal data would instead be done at trip table level

Zone/Network Relationships

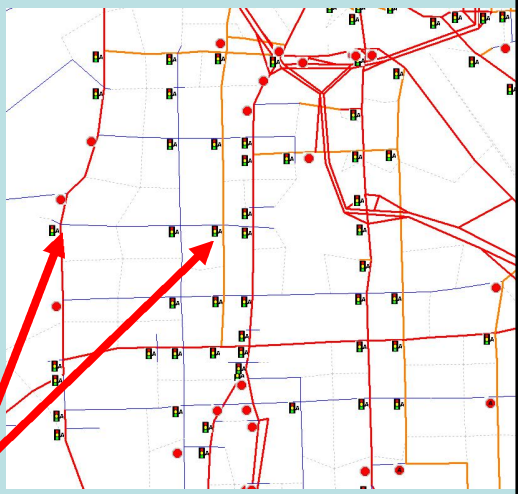
- There is a relationship between zones and the network that should have been correctly specified in the regional model
- Often, a project analysis will require additional minor roads be included in the model, which should then lead to additional zones, also additional zones might be added on their own to improve the modeling of access to the streets
- Networks and zones should be adjusted in project area when necessary

Zone/Network Relationships

- The modeled network should include the streets of interest (such as arterials and freeways) as well as one class lower (say collectors) and all cross streets and driveways that impose traffic control (signals, stop signs) on the modeled streets

Example: Network includes all freeways and arterials (red), collectors (orange) are included as well (1 class lower)

Note Inclusion of local roads (blue) that impose traffic control on these higher classed roads



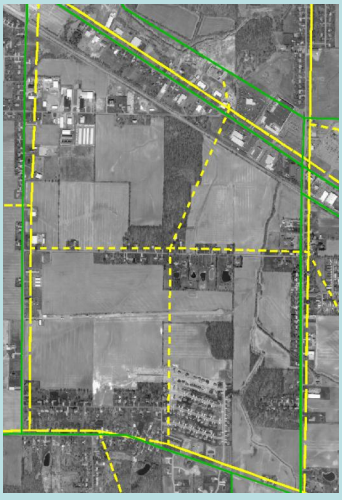
Zone/Network Relationships

- Zones should be defined based upon how the subject land use accesses the network as well as the number of roads being modeled (at a minimum the modeled roadway network should delineate zones)

Example: In this case the network (large dashed yellow lines) delineates a single area yet 8 zones (solid green lines) have been described due to the access pattern as shown by the centroid connectors (small dashed yellow lines)

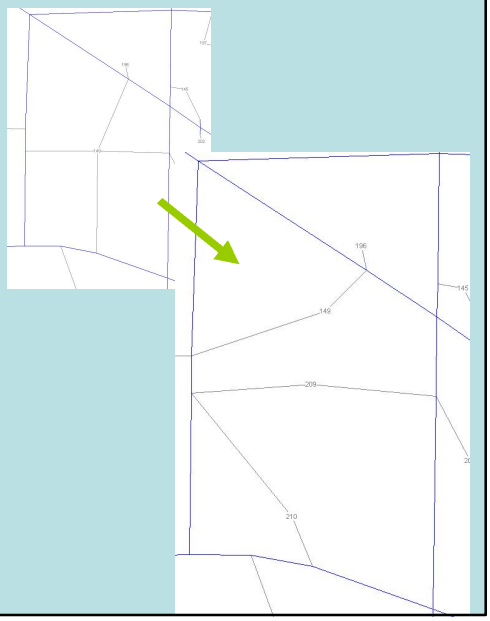
Splitting Zones

- The zone system that was considered adequate at the regional level must often be refined for project forecasting
- This zone is considered adequate regionally due to low activity level, despite the fact that not all of the zonal activity accesses the street system as depicted by the centroid connectors



Splitting Zones

- A project requiring turning movements at the indicated intersection (red arrow), however, requires greater detail for this zone



Model Adjustment

- The remaining topics are adjustments
- These can generally be broken into the following groups:
  - Speed adjustment
  - Special Generator Factors
  - Use Groups to Control Routing
  - Screenline Penalties
  - K Factors
  - Adjust the Inner Workings of the Model

Speed Adjustment

- Small adjustments in network speed are the primary model adjustment tool for project level work
- They should only be used after all reasonable refinements have occurred

Special Generators

- Once the networks and zones are at the correct level of detail for the project and all the subject data is correct, special generators (i.e. changing the amount of traffic generated by a zone) is the best way to refine the volumes produced by the model in the study area
- To employ them, zones must be sufficiently refined to isolate the land use
- The centroid connectors should be at the actual points of network access for the special generator

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	PURPFLA	TAZ	TYPEFLAG	CONSTAN	AREA_TYP	POP	WORKER	TOT_VEH	MED_HHI	TOT_HH	HOTEL_R	AVG_PAR	NAICS11	NAICS21	NAICS22	NAICS23	NAICS31	NAICS32
68	5	111	10	6.8														
69	5	134	10	-0.3														
70	3	136	31										11.04	11.04	11.04	11.04	11.04	11.04
71	3	137	31										22.23	22.23	22.23	22.23	22.23	22.23
72	5	145	10	-0.5														
73	5	147	10	-0.3														
74	5	159	10	3.8														
75	4	165	10	-0.3														
76	3	166	31										10.62	10.62	10.62	10.62	10.62	10.62
77	4	166	10	0.1														

Adjust the Inner Workings of the Model

- Certain very few large projects might warrant tinkering with the inner workings of the model
- However, this should be considered extremely rare and would require validation/calibration exercises of the same order of magnitude conducted for the original model of record
- Some examples could include:
  - Changing the default trip rates
  - Changing friction factors
  - Changing auto occupancy rates
  - Changing time of day rates
  - Changing value of time parameters

Advanced Analytic Techniques

- Beyond the TDF models, there is now a trend towards microsimulating traffic operations
- These techniques require highly accurate turn movement level traffic forecasts (often sub-hourly as well)
- Employment during the conceptual alternatives stage generally requires that a conceptual alternatives model be developed for the production of refined alternative level traffic
- The typical application is to use Matrix Estimation techniques to refine model OD data to match base year traffic counts

Matrix Estimation in Project Modeling

- Matrix estimation (ME) can be thought of as reverse traffic assignment, it is a process whereby an origin-destination trip table is estimated from link counts (or more correctly an existing OD trip table is adjusted to be consistent with counts)
- As this technique has become fairly common, a few notes are in order regarding its use

Matrix Estimation in Project Modeling

- ME should only be applied to a model that has undergone the highest level of checking/ refining/ adjusting
- The process will compensate for bad network coding/path building by adjusting OD flows (THIS IS BAD)
- Count consistency is very important when employing ME, counts coded on network must be thoroughly (even ruthlessly) checked

Matrix Estimation in Project Modeling

- The process produces a rather static trip table that cannot respond to changes in land use and the transportation system the way the travel demand model can
- Therefore, it is mainly useful for analyzing near term operational improvements to the system